

AMENDMENTS TO THE CLAIMS

A complete listing of all claims in the application is provided below.

Claim 1 (currently amended): An apparatus for use with a human body for brachytherapy comprising:

an injection device having a hollow injection needle with an opening at a tip and seed-depositing means for having a radioactive seed pushed therethrough to be deposited in a patient's body through said opening proximal to said tip;

seed-position detecting means ~~for~~ determining a position, with reference to a space-fixed coordinate system, of a seed deposited in the patient's body by said injection device;

real-time seed-position determining means ~~for~~ determining a position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body; and

dose calculating means ~~for~~ calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device.

Claim 2 (Currently amended): An apparatus for use with a human body for brachytherapy comprising:

an injection device having a hollow injection needle with an opening at a tip and seed-depositing means for having a radioactive seed pushed therethrough to be deposited in a patient's body through said opening proximal to said tip;

seed-position detecting means ~~for~~ determining a position, with reference to a space-fixed coordinate system, of a seed deposited in the patient's body by said injection device;

real-time seed-position determining means ~~for~~ determining a position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body; and

dose calculating means ~~for~~ calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device;

wherein said seed-position detecting means include:

energy transmitting means attached to said injection device for causing energy to be transmitted therefrom;

a detector at a fixed position with respect to said space-fixed coordinate system for receiving said energy propagated from said energy propagating means; and

means for determining position and orientation of said injection device based on the energy propagated from said energy propagating means and received by said detector and thereby determining position of said deposited seed from the position of said opening at said tip of said injection needle.

Claim 3 (Currently amended): An apparatus for use with a human body for brachytherapy comprising:

an injection device having a hollow injection needle with an opening at a tip and seed-depositing means for having a radioactive seed pushed therethrough to be deposited in a patient's body through said opening proximal to said tip;

seed-position detecting means ~~for~~ determining a position, with reference to a space-fixed coordinate system, of a seed deposited in the patient's body by said injection device;

real-time seed-position determining means ~~for~~ determining a position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body; and

dose calculating means ~~for~~ calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device;

wherein said real-time seed-position determining means include:

markers affixed to selected parts of said body for defining said body-fixed coordinate system;

reference point detecting means for detecting in real time reference point position data with respect to said space-fixed coordinate system on positions of at least portions of said markers; and

reference means ~~for~~ determining a position of said deposited seed with reference to said body-fixed coordinate system from the position of said seed determined by said seed-position detecting means and the reference point position data detected by said reference point detecting means.

Claim 4 (Original): The apparatus of claim 3 wherein at least one of said markers comprises a needle with a front end and a back end and inserted in said patient's body, a front end being attached to a radiation transmitting means for transmitting a position-

indicating signal for indicating the position of said front end, said back end being positioned outside of said patient's body so as to be observable by said seed-position detecting means.

Claim 5 (Original): The apparatus of claim 1 wherein said real-time position determining means includes:

memory means for storing earlier obtained patient's anatomical data; and
coordinate-transforming means for identifying said body-fixed coordinate system with reference to said earlier obtained patient's anatomical data and determining position of said deposited seed with reference to said body-fixed coordinate system from the position of said seed with respect to said space-fixed coordinate system determined by said seed-position detecting means.

Claim 6 (Original): The apparatus of claim 1 wherein said dose calculating means calculates a hypothetical radiation dose distribution by assuming that a seed has been hypothetically deposited at a hypothetically selected position in said patient's body.

Claim 7 (Original): The apparatus of claim 1 further comprising injector controlling means for making a comparison between said calculated radiation dose distribution and a predetermined distribution plan, determining a next seed position where a next seed should be deposited in said patient's body according to result of said comparison and controlling said injection device according to said determined next position.

Claim 8 (Original): The apparatus of claim 1 further comprising display means for providing in real time a visual display of said injection needle with reference to said body-fixed coordinate system as said injection needle is moved through said patient's body.

Claim 9 (Original): The apparatus of claim 3 further comprising display means for providing in real time a visual display of said reference point position data and the positions of deposited seeds.

Claim 10 (Currently amended): An apparatus for use with a human body for brachytherapy comprising:

an injection device having a hollow injection needle with an opening at a tip and seed-depositing means for having a radioactive seed pushed therethrough to be deposited in a patient's body through said opening proximal to said tip;

seed-position detecting means ~~for~~ determining a position, with reference to a space-fixed coordinate system, of a seed deposited in the patient's body by said injection device;

real-time seed-position determining means ~~for~~ determining a position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body;

dose calculating means ~~for~~ calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device; and

display means ~~for~~ providing in real time a visual display of ~~said~~ earlier obtained patient's anatomical data and the positions of deposited seeds;

wherein said real-time position determining means includes:
memory means for storing said earlier obtained patient's anatomical data; and
coordinate-transforming means for identifying said body-fixed coordinate system
with reference to said earlier obtained patient's anatomical data and determining position of
said deposited seed with reference to said body-fixed coordinate system from the position of
said seed with respect to said space-fixed coordinate system determined by said seed-position
detecting means.

Claim 11 (Original): The apparatus of claim 3 further comprising memory means
for storing earlier obtained patient's anatomical data; and
updating means for updating said earlier obtained patient's anatomical data by said
reference point position data detected by said reference point detecting means.

Claim 12 (Original): A method in brachytherapy comprising the steps of:
depositing a radioactive seed in a patient's body through an opening at a needle tip of
an injection device;
determining space-position of said deposited seed with reference to a space-fixed
coordinate system;
determining body-position of said deposited seed in real time with reference to a
body-fixed coordinate system which is affixed to said patient's body; and
calculating in real time a radiation dose distribution within a selected volume
specified with respect to said body-fixed coordinate system due to seeds which have been
deposited by said injection device.

Claim 13 (previously amended): A method in brachytherapy comprising the steps of:

depositing a radioactive seed in a patient's body through an opening at a needle tip of an injection device;

determining space-position of said deposited seed with reference to a space-fixed coordinate system;

determining body-position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body; and

calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device;

wherein the step of determining space-position of said deposited seed includes the steps of:

causing energy to be propagated from fixed positions on said injection device;

detecting said propagated energy by a detector at a fixed position with respect to said space-fixed coordinate system; and

assuming that said deposited seed is located where said opening at said needle tip of said injection device was when said seed was deposited.

Claim 14 (Original): The method of claim 12 wherein the step of determining said body-position of said deposited seed includes the steps of:

affixing markers to selected parts of said patient's body;

detecting said markers in real time by a detector which is affixed at a fixed position with reference to said space-fixed coordinate system; and

determining said body-position of said deposited seed from the detected positions of said markers and said determined space-position of said deposited seed.

Claim 15 (Original): The method of claim 14 wherein at least one of said markers comprises a needle with a front end and a back end, said front end being attached to a radiation transmitting means for transmitting a position-indicating signal, said back end being outside of said patient's body, said position-indicating signal being detected by a space-fixed signal detector.

Claim 16 (Original): The method of claim 12 wherein the step of determining said body-position of said deposited seed includes the steps of:

retrieving earlier obtained anatomical data on said patient's body;

determining said body-fixed coordinate system from said earlier obtained anatomical data; and

determining said body-position of said deposited seed from body-fixed coordinate system and said determined space-position of said deposited seed.

Claim 17 (Original): The method of claim 12 further comprising the steps of calculating hypothetical dose distribution by assuming that a seed has been hypothetically deposited at selected positions inside said patient's body and causing said calculated hypothetical dose distributions to be displayed.

Claim 18 (Original): The method of claim 12 further comprising the steps of:
making a comparison between said calculated radiation dose distribution and a predetermined distribution plan;
determining a next seed position where a next seed should be deposited in said patient's body according to result of said comparison; and
controlling said injection device according to said determined next position to inject a next seed at said determined next seed position.

Claim 19 (Original): The method of claim 12 further comprising the step of displaying an image of said injection needle in real time with reference to said body-fixed coordinate system as said injection needle is pushed through said patient's body.

Claim 20 (Original): The method of claim 14 further comprising the step of displaying in real time the positions of said markers and positions of seeds which have been deposited by said injection device.

Claim 21 (Original): The method of claim 16 further comprising the step of displaying in real time said earlier obtained anatomical data on said patient's body and positions of seeds which have been deposited by said injection device.

Claim 22 (Original): The method of claim 14 further comprising the steps of updating earlier obtained anatomical data on said patient's body by using the positions of said detected markers.

Claim 23 (previously amended): An apparatus for brachytherapy, comprising:
a seed delivery device comprising a position-indicating unit;
a position detector configured to sense said position-indicating unit; and
a computer coupled to said position detector, said computer configured to determine a position of a seed within a patient body with reference to a space-fixed coordinate system based on a position of said position-indicating unit, and a radiation dose distribution relative to a body-fixed coordinate system based at least on said position of said seed.

Claim 24 (Previously presented): The apparatus of claim 23, wherein said seed has been deposited by said seed delivery device.

Claim 25 (Previously presented): The apparatus of claim 23, wherein said seed is being carried by said seed delivery device.

Claim 26 (Previously presented): The apparatus of claim 23, wherein said position-indicating unit emits or reflects radiative energy.

Claim 27 (Previously presented): The apparatus of claim 26, wherein said radiative energy comprises ultrasonic energy or electromagnetic energy.

Claim 28 (Previously presented): The apparatus of claim 23, wherein said position detector comprises a camera.

Claim 29 (Previously presented): The apparatus of claim 23, further comprising a screen coupled to said computer.

Claim 30 (Previously presented): The apparatus of claim 29, wherein said screen provides a visual display of said seed delivery device with reference to said body-fixed coordinate system.

Claim 31 (Previously presented): The apparatus of claim 29, wherein said screen provides a visual display of said deposited seed.

Claim 32 (previously amended): A method in brachytherapy, comprising:
placing a radioactive seed in a patient's body via a delivery device;
determining a position of said seed with reference to a space-fixed coordinate system;
determining a body-fixed coordinate system based on markers within said patient's body; and
calculating a radiation dose distribution relative to said body-fixed coordinate system due to said seed.

Claim 33 (Previously presented): The method of claim 32, further comprising releasing said seed from said delivery device.

Claim 34 (Previously presented): The method of claim 32, wherein said determining a position of said seed comprises sensing a position-indicating unit carried on said delivery device.

Claim 35 (Previously presented): The method of claim 34, wherein said sensing comprises detecting radiative energy emitted or reflected by said position-indicating unit.

Claim 36 (Previously presented): The method of claim 35, wherein said radiative energy comprises ultrasonic energy or electromagnetic energy.

Claim 37 (Previously presented): The method of claim 34, wherein said sensing is performed using a camera.

Claim 38 (Previously presented): The method of claim 32, wherein said determining a body-fixed coordinate system comprises determining positions of said markers.

Claim 39 (Previously presented): The method of claim 38, wherein said determining positions of said markers comprises using an X-ray imaging system, an ultrasonic imaging system, a MRI system, or a CT system.

Claim 40 (Previously presented): The method of claim 32, further comprising displaying said delivery device with reference to said body-fixed coordinate system on a screen.

Claim 41 (previously amended): An apparatus for brachytherapy, comprising:
a seed delivery device comprising a position-indicating unit;
a position detector configured to sense said position-indicating unit;
an imaging system configured to sense markers within a patient body; and
a computer coupled to said position detector and said imaging system, said computer configured to determine a position of a seed with reference to a space-fixed coordinate system based on a position of said position-indicating unit, a body-fixed coordinate system based on positions of said markers, and a radiation dose distribution relative to said body-fixed coordinate system based at least on said position of said seed with reference to said space-fixed coordinate system.

Claim 42 (Previously presented): The apparatus of claim 41, wherein said seed has been deposited by said seed delivery device.

Claim 43 (Previously presented): The apparatus of claim 41, wherein said seed is being carried by said seed delivery device.

Claim 44 (Previously presented): The apparatus of claim 41, wherein said position-indicating unit emits or reflects radiative energy.

Claim 45 (Previously presented): The apparatus of claim 44, wherein said radiative energy comprises ultrasonic energy or electromagnetic energy.

Claim 46 (Previously presented): The apparatus of claim 41, wherein said position detector comprises a camera.

Claim 47 (previously amended): An apparatus for brachytherapy, comprising:
a seed delivery device comprising a position-indicating unit;
a position detector configured to sense said position-indicating unit;
markers within a patient body;
an imaging system configured to sense said markers; and
a computer coupled to said position detector and said imaging system, said computer configured to determine a position of a seed with reference to a space-fixed coordinate system based on a position of said position-indicating unit, a body-fixed coordinate system based on positions of said markers, and a radiation dose distribution relative to said body-fixed coordinate system based at least on said position of said seed with reference to said space-fixed coordinate system.

Claim 48 (previously amended): The apparatus of claim 41, wherein said markers comprise pins.

Claim 49 (previously amended): The apparatus of claim 48, wherein said markers comprise energy-transmitting position sources.

Claim 50 (Previously presented): The apparatus of claim 41, wherein said imaging system comprises an X-ray imaging system, an ultrasonic imaging system, a MRI system, or a CT system.

Claim 51 (Previously presented): The apparatus of claim 41, further comprising a screen coupled to said computer.

Claim 52 (Previously presented): The apparatus of claim 51, wherein said screen provides a visual display of said seed delivery device with reference to said body-fixed coordinate system.

Claim 53 (currently amended): The apparatus of claim 1 further comprising reference point detecting means for detecting in real time reference point position data with respect to said space-fixed coordinate system on positions of at least portions of markers affixed to selected parts of said body, and a display means for providing in real time a visual display of said reference point position data and the positions of deposited seeds.

Claim 54 (currently amended): An apparatus for use with a human body for brachytherapy comprising:

an injection device having a hollow injection needle with an opening at a tip and seed-depositing means for having a radioactive seed pushed therethrough to be deposited in a patient's body through said opening proximal to said tip;

seed-position detecting means ~~for~~ determining a position, with reference to a space-fixed coordinate system, of a seed deposited in the patient's body by said injection device;

real-time seed-position determining means ~~for~~ determining a position of said deposited seed in real time with reference to a body-fixed coordinate system which is affixed to said patient's body;

dose calculating means ~~for~~ calculating in real time a radiation dose distribution within a selected volume specified with respect to said body-fixed coordinate system due to seeds which have been deposited by said injection device; and

display means ~~for~~ providing in real time a visual display of ~~said~~ earlier obtained patient's anatomical data and the positions of deposited seeds.